3- Monte Carlo 'article-in-Cell Simulations of Ion Thruster Plumes under Ground Test and Flight Conditions

J Wang, J Brophy, and P. Liewei
Jet Propulsion ,aboratory, California Institute of Technology

Ion thrusters are valued as a high-specific inpluse class of space propulsion system. One of the major concerns, however, is the potential for contamination produced by the exhaust plume. The exhaust plume, which is a partially ionized gas, produces a low-energy plasma through charge-exchange collisions The charge-exchange plasma can leave the primary plume and flow upstream around the spacecraft. In addition plasma waves and instabilities can be generated by the acceleration of charged particles. The plasma plume has the potential for various adverse effects on the host spacecraft and critical payloads sucl as contamination of critical spacecraft surfaces and optical sensors, spacecraft charging, and electromagnetic nterference. While previous fligl t experiments have shown that these effects are negligible for spacecraft engineering subsystems, the issue remains for sensi ive scientific nstruments. To baseline the use of ion thrusters, NASA is planning a flight demonstration experiment (NSTA). This paper discusses our modeling effort in support of the NSTAR program.

A fully three-dimensional particle-in-cell with Monte Carlo collisions (PIC-MCC) code is developed to model ion thruster plumes. In the model, ions and neutrals are ejected from the thruster, and electrons are ejected from the neutralizer. To capture the full kinetic behaviour of the plume, both the electrons and ions are treated as test particles. The code follows the evolution of the orbits of individual test particles i e self-consistent electric field. The charge-exchange collisions within the plume are calculated using a Monte Carlo collision model. Two ion thruster plume models are developed. The first one, the ground test model, is set to simulate ground tests. In this model, the simulation setup is similar to that of the ongoing tests of ion thrusters at JPL and the wall effects of the test chamber are included. The second one, the space flight model, is used to simulate the plume under flight conditions. The ambient plasma and the geomagnetic field are also included in the second model. The numerical results will be compared with that from ground tests, and the effects of test chamber on plume measurements will be discussed. The backflow of the charge-exchange ions under the flight condition will be compared with that under the ground test condition. Preflight predictions will also be discussed.

3-D PIC-MCC simulations are extremely computational intensive. The simulations conduced here utilize massively parallel supercomputers (Intel Paragon and Cray T3D). Some parallel computing issues related to our simulation will also be discussed.